

AI-Based Construction Safety System: A Review

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ABSTRACT

Construction sites are considered one of the most hazardous working environments due to accidents caused by unsafe practices, equipment failures, and lack of real-time monitoring. Artificial Intelligence (AI) has emerged as an effective technology for improving safety management in the construction industry. AI-based construction safety systems use technologies such as machine learning, computer vision, Internet of Things (IoT), wearable sensors, and deep learning to identify risks, monitor workers, and prevent accidents. This review paper presents an overview of AI-based construction safety systems, their working principles, applications, advantages, limitations, and future developments. The study highlights how AI techniques are used for helmet detection, fall detection, hazard prediction, worker tracking, and equipment monitoring. The integration of AI with smart cameras and sensors enables real-time safety analysis and rapid decision-making. Although AI systems improve efficiency and reduce human error, challenges such as high implementation cost, data privacy, and technical complexity still exist. The review concludes that AI-based safety systems can significantly enhance worker protection and reduce accidents in modern construction projects.

Keywords-Artificial Intelligence; Construction Safety; Machine Learning; Computer Vision; IoT; Hazard Detection

1. INTRODUCTION

Construction industries contribute significantly to infrastructure development and economic growth. However, construction sites involve dangerous operations such as working at heights, heavy machinery handling, and electrical activities. These conditions increase the risk of injuries and fatalities.

Traditional safety management methods mainly depend on manual inspection and human supervision, which are often inefficient. Artificial Intelligence (AI) technologies provide smart and automated solutions for improving construction safety. AI systems can continuously monitor construction activities, identify unsafe conditions, and generate warnings before accidents occur.

The rapid growth of AI technologies such as machine learning, computer vision, robotics, and wearable devices has transformed construction safety management. AI-based safety systems help in improving productivity, reducing human errors, and ensuring safer working conditions.

2. AI IN CONSTRUCTION SAFETY

Artificial Intelligence refers to computer systems capable of performing tasks that normally require human intelligence. In construction safety management, AI is used to analyze data, recognize patterns, and make safety-related decisions.

The major AI technologies used in construction safety systems include:

A. Machine Learning

Machine learning algorithms analyze historical accident data and predict potential hazards. These systems learn from previous incidents and improve safety recommendations over time.

B. Computer Vision

Computer vision systems use cameras and image processing techniques to monitor workers and detect unsafe behaviors such as:

- i. Absence of helmets or safety vests
- ii. Unsafe movement near machinery
- iii. Fall detection
- iv. Entry into restricted zones

C. Internet of Things (IoT)

IoT devices such as smart sensors and wearable devices collect real-time information related to worker location, temperature, gas leakage, and equipment conditions.

D. Deep Learning

Deep learning models improve object detection and image recognition accuracy. These models are widely used in surveillance systems for identifying construction hazards.

3. WORKING OF AI-BASED CONSTRUCTION SAFETY SYSTEM

The AI-based safety system generally consists of the following stages:

- i. Data Collection using cameras, drones, and sensors
- ii. Data Processing using AI algorithms
- iii. Hazard Detection and Risk Analysis
- iv. Alert Generation and Notification
- v. Safety Monitoring and Reporting

The collected data are processed continuously to identify unsafe activities. If a hazard is detected, the system immediately generates warnings to workers and site managers.

4. APPLICATIONS OF AI-BASED CONSTRUCTION SAFETY SYSTEM

A. Helmet and PPE Detection

AI systems automatically detect whether workers are wearing Personal Protective Equipment (PPE) such as helmets, gloves, and safety jackets.

B. Fall Detection Systems

Computer vision and wearable sensors identify worker falls and immediately send emergency alerts.

C. Worker Tracking

GPS and IoT-based systems track worker locations to avoid collisions and unauthorized access to dangerous zones.

D. Equipment Safety Monitoring

AI systems monitor cranes, excavators, and other heavy machinery to detect abnormal conditions and prevent failures.

E. Hazard Prediction

AI algorithms analyze previous accident records and environmental conditions to predict future risks.

5. ADVANTAGES OF AI-BASED CONSTRUCTION SAFETY SYSTEM

The major advantages are:

- i. Reduction in workplace accidents
- ii. Real-time monitoring and analysis
- iii. Improved worker safety awareness
- iv. Faster emergency response
- v. Reduction in human errors
- vi. Better project management efficiency
- vii. Continuous safety inspection without fatigue

6. LIMITATIONS AND CHALLENGES

Despite several advantages, AI-based construction safety systems face certain limitations:

- i. High installation and maintenance costs
- ii. Requirement of large training datasets
- iii. Privacy concerns related to worker monitoring

- iv. Dependence on internet and sensor connectivity
- v. Technical complexity in system implementation
- vi. Possibility of false alarms and inaccurate detection

7. FUTURE SCOPE

Future AI-based construction safety systems are expected to include advanced robotics, autonomous drones, augmented reality, and digital twin technology. Integration with 5G communication and cloud computing will improve system speed and accuracy.

AI systems may also provide predictive safety analytics capable of preventing accidents before unsafe conditions arise. Smart wearable devices with health monitoring features will further enhance worker protection.

8. CONCLUSION

AI-based construction safety systems play an important role in improving workplace safety and reducing accidents in the construction industry. Technologies such as machine learning, computer vision, IoT, and deep learning enable continuous monitoring and intelligent hazard detection. Although challenges related to cost, privacy, and technical implementation exist, AI systems provide significant benefits in ensuring worker safety and operational efficiency. The future of construction safety will largely depend on the integration of AI technologies with smart infrastructure and automation systems

Table 1 Comparison of Traditional and AI-Based Safety Systems

Parameter	Traditional Safety System	AI-Based Safety System
Monitoring	Manual	Automated
Hazard Detection	Slow	Real-Time
Accuracy	Moderate	High
Human Dependency	High	Low
Response	Time Delayed	Immediate
Data Analysis	Limited	Advanced

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